DRAPE OF APPAREL FABRICS

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DRAPE OF APPAREL FABRICS

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ABSTRACT

By using the Drapemeter, drape coefficients (drape) for 101 apparel fabrics were calculated to be between 14 and 95 percent, extending over most of the theoretical range of 0 to 100 percent. Drape coefficient was highly correlated with lengthwise and crosswise bending length and moderately correlated with flexural rigidity. Drape diagrams also provide information about drape characteristics. **KEYWORDS: clothing textiles, drape, drape coefficients of clothing textiles, textiles, textile bending length, textile flexural rigidity, textile stiffness.**

INTRODUCTION

Although certain qualities of textiles are usually evaluated subjectively, investigators have attempted to characterize previously accepted subjective phenomena by objective measurements (*2–4, 10–13, 14–16, 18*).[2] Interest in the measurement of hand and drape has occurred in Japan, England, and the United States (*9–11, 17, 19*). Softness and hand of nonwoven surgical or hospital textile materials were evaluated by using 13 different instruments and 6 subjective panels in 1974 (*8*). Little information about drape (drape coefficient) of apparel fabrics is available. This investigation explored the use of the Drapemeter for evaluating drape, one facet of the esthetics of consumer apparel textiles, and the correlation between drape and stiffness.

MATERIALS AND METHODS

Yardages and remnants of over-the-counter staple and fancy fabrics were purchased to represent a variety of stiffness, as appreciated by the fingers. Experimental fabrics, manufacturers' samples of coated textiles, and several swatches from home sewers were included as comparison fabrics (*5*). The collection of 101 fabrics included woven, knitted, and nonwoven textiles.

To aid in the identification of fabrics, a few construction characteristics were determined. American Society for Testing and Materials (ASTM) methods, Federal Test Methods, and nonstandardized methods to determine stiffness, bending length, flexural rigidity, and drape are listed in table 1. Although the Gurley Stiffness Tester was developed for the paper industry, it is also recommended for testing textiles. In preliminary testing of 13 fabrics ranging from a stiff, rainproof cotton to a limp, single knit, our results were not reproducible. Therefore, use of the Gurley Tester was discontinued temporarily.

Drape is characterized as "drape coefficient." By using the Drapemeter, a form of overhead projector, a 10-in-diameter specimen is draped over a 4-in-diameter circular table. A light and lens located below the specimen projects a shadow of the specimen shape upward. The image is traced onto paper and cut out. Drape coefficient (F) is defined as the percentage of the area of the annular ring of fabric (less the supporting ring) obtained by vertically projecting the shadow of the drape specimen (less the supporting ring):

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[2] Italic numbers in parentheses refer to items in "Literature Cited" at the end of this publication.

$$F = \frac{\text{weight of projected image} - \text{weight of 4-in-diameter paper}}{\text{weight of 10-in-diameter paper} - \text{weight of 4-in-diameter paper}} \times 100 \quad (1)$$

Drape coefficient can theoretically range from 0 to 100 percent; the lower the drape coefficient, the greater the drape. Since the drape coefficient does not give a complete description of drape behavior, a few researchers have studied drape diagrams, the projected two-dimensional image of the three-dimensional draped specimen (*5, 7, 17*). Stiffness of a fabric too flexible or limp to be tested by the usual cantilever test can be measured by the hanging heart loop option of the same test, ASTM D 1388–64 (*1*).

RESULTS AND DISCUSSION

Table 2 identifies fabrics by increasing weight, from a sheer suitable for party dresses to a nubby wool coating. Complete specifications were not available for all fabrics. Whenever available, a manufacturer's designation or trade name was used for identification.

Average drape coefficients are given in table 2. Drape-coefficient values were assigned to categories arbitrarily designated as "limp," "limp, high drape," "average drape," "moderately stiff," "stiff," "quite stiff," and "very stiff or boardy." Table 3 lists the categories defined by a range of drape coefficients, together with the types of fabric that produced drape coefficients within a range; the two intervals of "limp" and "limp, high drape" were combined.

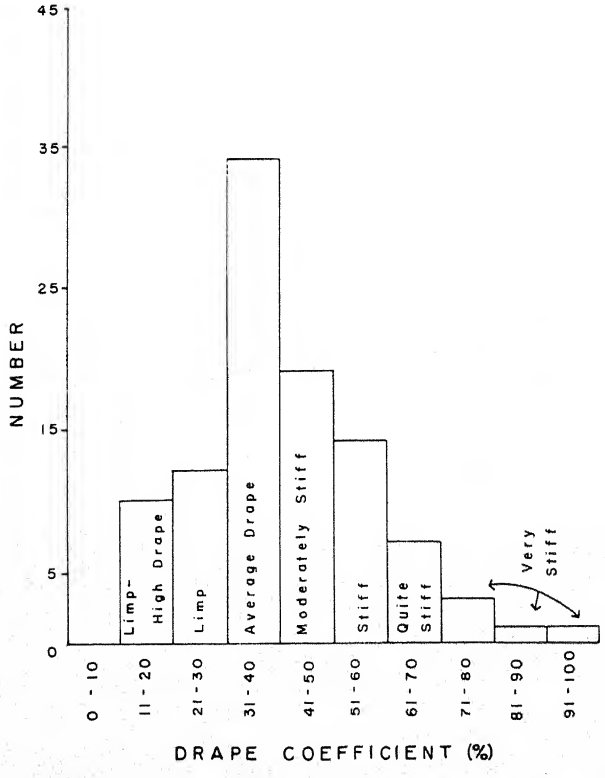

FIGURE 1.—Frequency distribution of drape coefficients.

TABLE 1.—*Fabric properties and test methods*

Property	Method
Stiffness	Hanging heart loop; Instructions and Factor Table for Gurley Stiffness Tester.[1]
Bending length	ASTM: D 1388–64 (reapproved 1975).
Flexural rigidity	ASTM: D 1388–64 (reapproved 1975).
Fabric count	ASTM: D 231–62 (reapproved 1975), D 1910–64 (reapproved 1975).
Fabric weight	ASTM: D 1910–64 (reapproved 1975).
Drape coefficient	"Operating Instructions, FRL Drapemeter," IMASS, Accord, Mass.

[1] See references *1* and *6*.

The range of drape coefficients was from 14 percent for an acetate tricot jersey to 95 percent for a polyester nonwoven interfacing, extending over most of the theoretical range of 0 to 100 percent. Figure 1 displays the frequency distribution, by intervals of 10 percent, of drape coefficients of the 101 fabrics. Two experimental 50 percent polyester and 50 percent cotton broadcloths, identical except for differences in durable-press finishes, produced drape coefficients of 36 and 42 percent. For only a few fabrics were drape coefficients of face and reverse side different; therefore, means of face and reverse side are reported.

In the cantilever test for stiffness, the overhang of a single-knit cotton jersey could not be measured because specimens curled. A number of other fabrics had a tendency to curl. A small amount of variability among specimens from the same fabric can be expected. A plain weave does not necessarily result in a fabric with a plain or smooth surface effect, for example, in poplin and dimity. Applied design or structural details appeared to cause considerable variation among specimens removed side by side. For

(*Continued on page 5.*)

TABLE 2.—*Selected physical properties of apparel fabrics*

[In order of increasing fabric weight]

Description or designation[1]	Weight (oz/yd²)	Count[2]		Flexural rigidity[3] (mg/cm²)	Drape coefficient (percent)
		Warp (number)	Filling (number)		
Sheer, trilobal monofilament	0.5	113	107	27	54
Tricot, lingerie sheer	.9	42	51	8	39
Sheer, trilobal nylon, monofilament	1.4	208	136	90	52
Cheesecloth	1.5	43	35	28	32
Plain weave, Qiana nylon	1.5	127	95	15	24
Chiffon, filament	1.5	100	88	17	19
Underlining, polyester, plain weave	1.6	112	63	66	47
Underlining, lining, manmade fiber	1.8	72	64	32	27
Applique polyester, trilobal, plain weave	1.9	136	100	124	62
Twill, Ultressa polyester	2.2	116	81	28	28
Printcloth, blend	2.3	156	77	75	40
Interfacing, nonwoven, polyester	2.3	(4)	(4)	1,422	95
Voile, blend, DP	2.4	70	63	90	46
Do	2.4	72	64	90	52
Gingham, blend, DP	2.6	86	56	99	44
Dimity, blend, DP	2.6	61	43	163	55
Broadcloth, blend	2.7	133	78	64	43
Broadcloth, 20 cotton/80 polyester, Exp.	2.8	136	81	54	37
Do	2.8	136	85	61	35
Taffeta	3.0	180	162	496	80
Shantung, Qiana nylon	3.0	90	72	50	33
Broadcloth, 65 cotton/35 polyester, DP, Exp.	3.0	137	69	58	36
Shantung, texturized polyester	3.0	126	76	64	35
Fancy-deflected yarn and leno, blend	3.1	104	52	85	46
Taffeta, lining	3.1	62	202	80	41
Printcloth, blend	3.2	123	69	160	34
Broadcloth, 65 cotton/35 polyester, Exp.	3.2	138	72	80	38
Calico, cotton, w/w	3.2	80	70	88	44
Broadcloth, 50 cotton/50 polyester, Exp.	3.3	104	56	81	36
Broadcloth, 65 cotton/35 polyester, Exp.	3.3	139	71	46	31
Broadcloth, 50 cotton/50 polyester, Exp.	3.3	104	53	141	42
Broadcloth, cotton, w/w	3.3	85	68	64	33
Printcloth, blend	3.3	86	65	60	29
Plissé, DP	3.3	71	66	524	72
Taffeta, polyester, Testfabric	3.3	44	42	652	74
Printcloth, cotton	3.4	88	77	70	34
Do	3.4	80	65	53	30
Sheeting, cotton	3.5	103	55	94	30
Single knit, blend	3.4	30	31	20	15
Broadcloth	3.5	103	55	77	36
Do	3.6	112	54	70	35
Muslin, cotton, unbleached	3.6	86	80	61	33
Poplin, cotton	3.7	142	60	82	36
Satin, pima cotton	3.7	109	90	82	33
Oxford shirting, cotton	3.8	94	47	80	32
Single knit cotton jersey	3.8	31	34	(4)	15
Broadcloth, blend, w/w	3.8	140	64	86	35
Seersucker, blend, DP	3.9	73	67	179	53
Crepe, texturized polyester	3.9	88	68	72	31
Crepe, polyester, flocked design	4.0	95	73	143	37
Seersucker, blend	4.0	73	67	194	63
Printcloth	4.1	117	59	69	40
Satin, polyester	4.2	120	84	70	28
Single knit, Jacquard, manmade fiber	4.2	18	38	24	17

See footnotes at end of table.

TABLE 2.—*Selected physical properties of apparel fabrics*—Continued

[In order of increasing fabric weight]

Description or designation[1]	Weight (oz/yd²)	Count[2]		Flexural rigidity[3] (mg/cm²)	Drape coefficient (percent)
		Warp (number)	Filling (number)		
Flannel, cotton, FR	4.3	44	43	84	36
Glazed cotton, plain weave	4.3	70	52	123	48
Polyester, texturized, woven design	4.7	68	49	375	52
Tricot jersey, acetate	4.7	32	30	16	14
Chintz, cotton, glazed	4.9	73	61	356	63
Kettlecloth	4.9	63	49	228	58
Satin, acetate and nylon	4.9	133	65	52	23
Poplin, polyester and cotton	5.0	106	60	135	38
Poplin cotton, w/w	5.1	105	44	214	52
Single knit, eyelet, pigment print	5.1	(4)	(4)	33	20
Satin, lining	5.1	118	65	354	51
Pique, embossed polyester	5.2	(4)	(4)	473	63
Boucle, novelty yarn, plain weave	5.3	27	27	43	18
Poplin, polyester and cotton	5.5	105	50	197	52
Duck, sportswear, blend	5.5	106	50	203	52
Basketweave, cotton, DP	6.1	100	33	191	37
Suiting, twill, polyester	6.3	72	48	188	38
Tricot jersey, 90 cotton/60 acrylic, Exp.	6.3	41	37	79	20
Flannel, wool, washable	6.5	35	28	123	24
Duck, sportswear	6.6	114	34	336	55
Tricot jersey, 80 cotton/20 acrylic, DP, Exp.	6.6	41	38	77	19
Tricot jersey, 60 cotton/40 acrylic, DP, Exp.	6.6	40	38	84	18
Coated fabric, leather, shiny, Exp.	6.8	(4)	(4)	217	47
Linen, CR	6.9	45	32	264	38
Do	6.9	44	34	268	36
Tricot jersey, 70 cotton/30 acrylic, DP, Exp.	7.0	39	40	87	21
Double knit, blister, small pattern	7.0	28	19	150	27
Double knit, interlock	7.0	(4)	(4)	96	26
Suiting, twill, acrylic	7.0	28	23	202	40
Twill, work, cotton	7.6	115	52	406	55
Sateen, work, cotton	7.6	88	52	314	40
Flannel, wool, washable	7.8	35	32	167	34
Suiting, twill, manmade fiber	7.9	31	25	308	43
Homespun, blend	7.9	28	26	1,304	68
Sateen, work, DP	8.0	85	49	319	42
Twill, work, cotton, DP	8.0	110	53	554	64
Suiting, twill, manmade fiber	8.0	148	61	242	44
Serge, worsted	8.2	68	66	217	37
Suiting, linen-weave, blend	8.4	27	27	292	41
Twill, work, cotton, DP	8.5	84	54	377	48
Linen, CR	8.6	31	27	378	50
Pile, filling knit, acrylic	8.8	22	18	462	47
Leather, coated, dull, texture	9.4	(4)	(4)	1,150	68
SuperSuede (triacetate and nylon)	10.2	(4)	(4)	338	45
Twill, cotton, DP	11.1	70	45	999	89
Suede, flock on single knit	11.8	(4)	(4)	643	52
Wool coating, nubby	12.0	28	21	420	42

[1] DP: durable press; Exp.: experimental; w/w: wash and wear; FR: flame retardant; CR: crease resistant.

[2] Warp or wales; filling or courses.

[3] Geometric mean of warp×filling.

[4] Not available.

example, in a polyester and cotton seersucker having stripes of uneven width and in a polyester crepe with applied surface design, overhang values ranged by 2.9 and 3.6 cm, respectively.

For a plissé, with an excessively stiff finish, average warp bending length was 4.6 cm. For a dimity, a plain weave with lengthwise cords, bending length was 4.4 cm. Except for the dimity and the plissé, bending lengths of the fabrics were between 1.0 and 4.0 cm. The filling bending length was less, in general, than the warp.

Flexural-rigidity values for more than 70 percent of the fabrics fell between 9 and 277 mg/cm^2 in the warp direction (fig. 2). Approximately 50 percent of the fabrics produced average values between 40 and 159 mg/cm^2. Remaining values were widely scattered from 293 to 1,875 mg/cm^2 and therefore were not plotted in figure 2. Since the filling is usually less stiff than the warp, it was expected that flexural rigidity values would be lower, and this difference is seen by comparing figures 2 and 3. Approximately 86 percent of the values for filling were between 7 and 279 mg/cm^2,

TABLE 3.—*Categories of drape based on drape coefficients, with examples of fabrics in each category*[1]

LIMP; LIMP, HIGH DRAPE—DRAPE COEFFICIENTS: 11%–30%	
Chiffon	Plain weave, Qiana nylon
Double knit: blister and interlock	Satin, acetate and nylon
Flannel, wool, washable	Single knit, eyelet, pigment print
Tricot jersey, acetate	Single knit, blend
Twill, Ultressa polyester	Underlining
Single knit, Jacquard, manmade fiber	Satin, polyester
AVERAGE DRAPE—DRAPE COEFFICIENTS: 31%–40%	
Crepe, texturized polyester	Printcloth, blend
Linen, CR	Suiting, blend, linen-weave
Flannel, wool, washable	Broadcloth
Serge, worsted	Shantung, Qiana nylon
Muslin, cotton, unbleached	Oxford shirting, cotton
Suiting, twill, manmade fiber	Poplin, polyester/cotton
Sateen, work, cotton	Satin, pima cotton
Cheesecloth	Flannel, cotton, FR
Suiting, twill, acrylic	Tricot, lingerie sheer
MODERATELY STIFF—DRAPE COEFFICIENTS: 41%–50%	
Voile, blend, DP	Twill, work, cotton
Taffeta, lining	Suiting, twill, manmade fiber
Broadcloth, blend	Gingham
Sateen, work, cotton	SuperSuede
Coated fabric, leather, shiny	Calico, cotton, w/w
Chintz, cotton, glazed	Wool coating, nubby
Fancy-deflected yarn and leno, blend	Underlining
STIFF DRAPE—DRAPE COEFFICIENTS: 51%–60%	
Sheer, trilobal monofilament	Poplin, cotton
Satin, lining	Kettlecloth
Duck, sportswear	Dimity
Voile	Suede, flock on knit
Seersucker blend	
QUITE STIFF—DRAPE COEFFICIENTS: 61%–70%	
Homespun, blend, manmade fiber	Chintz, cotton, glazed
Twill suiting, blend	Pique polyester, embossed
Coated fabric, leather, dull texture	Applique, filament, embossed
VERY STIFF OR BOARDY—DRAPE COEFFICIENTS: OVER 71%	
Taffeta	Twill, work, cotton, DP
Interfacing, nonwoven polyester	Plissé, DP

[1] CR: crease resistant; FR: flame retardant; DP: durable press; w/w: wash and wear.

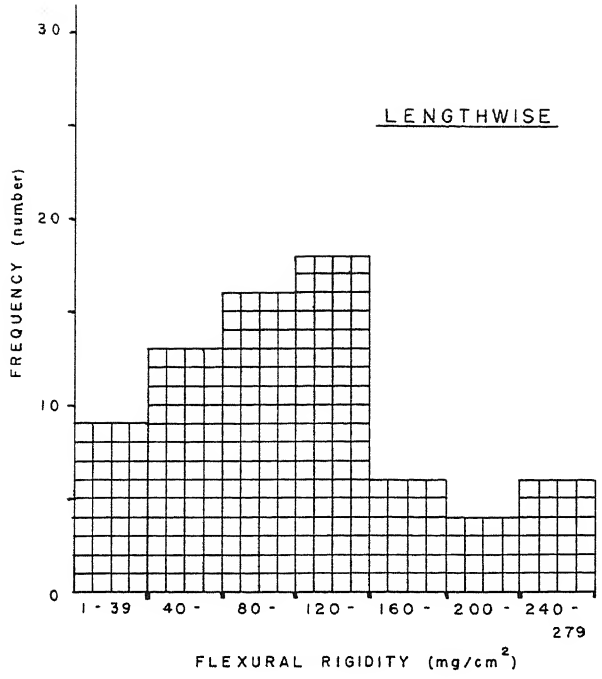

FIGURE 2.—Lengthwise flexural rigidity (stiffness) values for 72 of the 101 fabrics. Values were between 9 and 277 mg/cm².

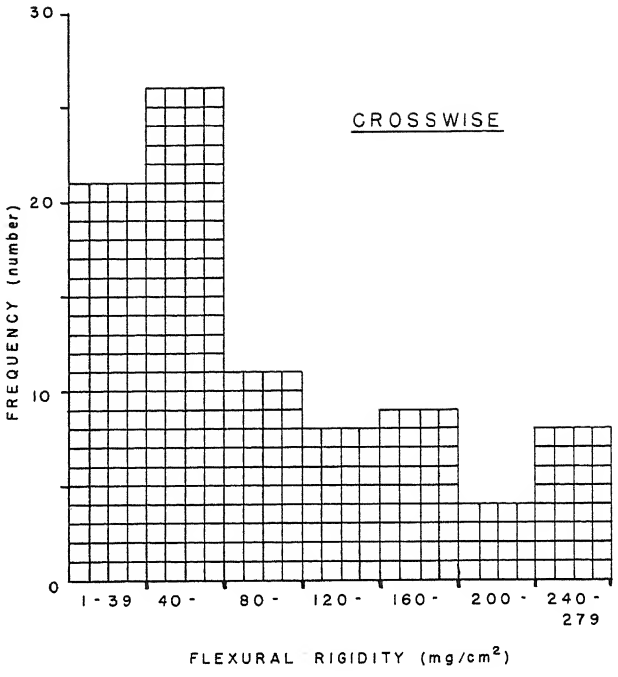

FIGURE 3.—Crosswise flexural rigidity (stiffness) values for 86 of the 101 fabrics. Values were between 7 and 279 mg/cm².

and for the remaining 14 fabrics, 320 to 2,131 mg/cm².

Stiffness of 32 fabrics was evaluated by the hanging heart loop test. Because the cotton and acrylic tricot 1-in-width specimens curled, the alternative 2- or 3-in-width specimens were tried. For the tricots, the 2-in-width specimens allowed for more accurate measurement of loop length. Data for the 3-in-width specimens were approximately the same as for the 2-in-width specimens, but the 2-in-width specimens were easier to handle. In general, the greatest lengths of loop, 3.28 to 4.02 in, were associated with the lowest drape coefficients, that is, fabrics with a greater drape. The shortest lengths in loop, 2.00 to 2.28 in, occurred in stiff fabrics having high drape coefficients.

Drape coefficient was highly correlated with lengthwise and crosswise bending length, as shown by coefficients of linear correlation of 0.87 and 0.82 (with standard errors of 0.02 and 0.03), respectively. Figures 4 and 5 illustrate the relation between the two properties. A marked degree of correlation between drape coefficient and warp, filling, and overall flexural rigidity was indicated by correlation coefficients of 0.75, 0.68, and 0.74, respectively. Slightly lower correlation coefficients for flexural rigidity, compared to bending length, are probably due to an inverse relationship of stiffness to weight in a few of the apparel fabrics.

Figure 6 represents the drape diagram for a filament jersey that produced 11 nodes and a low drape coefficient (*5*). The number of nodes per specimen ranged from 0 to 8 for the 101 fabrics. Zero nodes can be described as a shadow made by a specimen that sagged only slightly without forming definite nodes. If a specimen was disturbed or retested, the shadow often changed by one to two nodes, for example from three to four, or four to six nodes. The change in the number of nodes had no influence on drape coefficient for that specimen.

Drape diagrams were sorted by types of configuration. Among the slightly distorted circles and elliptical shapes were many of more irregular contour, one dubbed "Christmas bell without clapper" for the three nodes of rounded protuberances. Examples of drape diagrams are shown in figure 7. Within a fabric, consistency of configuration varied from high to almost none, and there seemed to be little agreement

(*Continued on page 8.*)

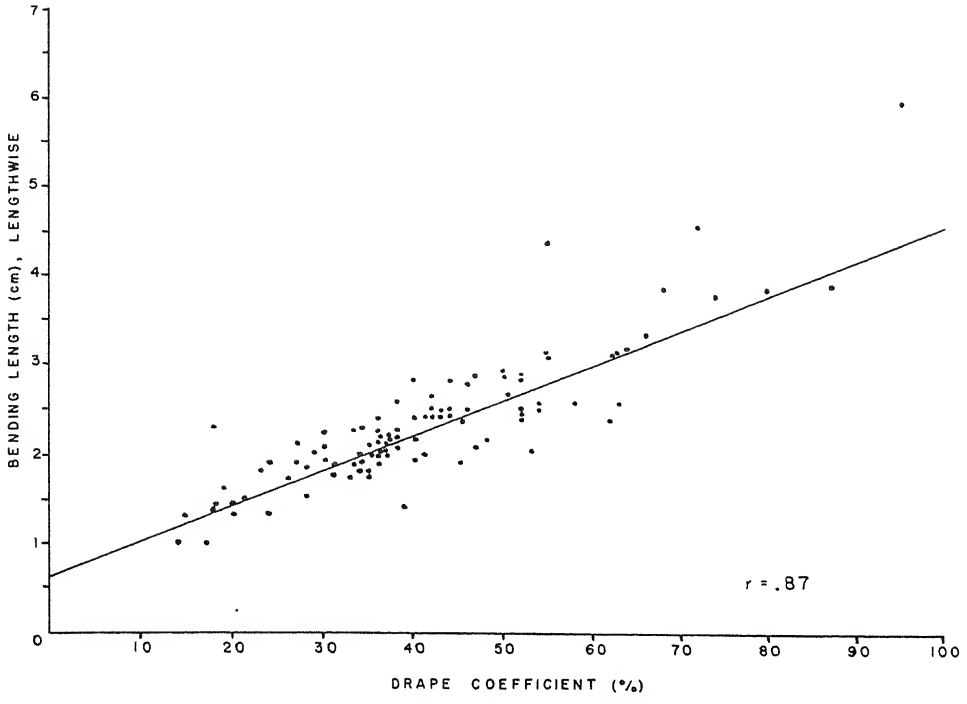

FIGURE 4.—Relation between lengthwise bending length and drape coefficient.

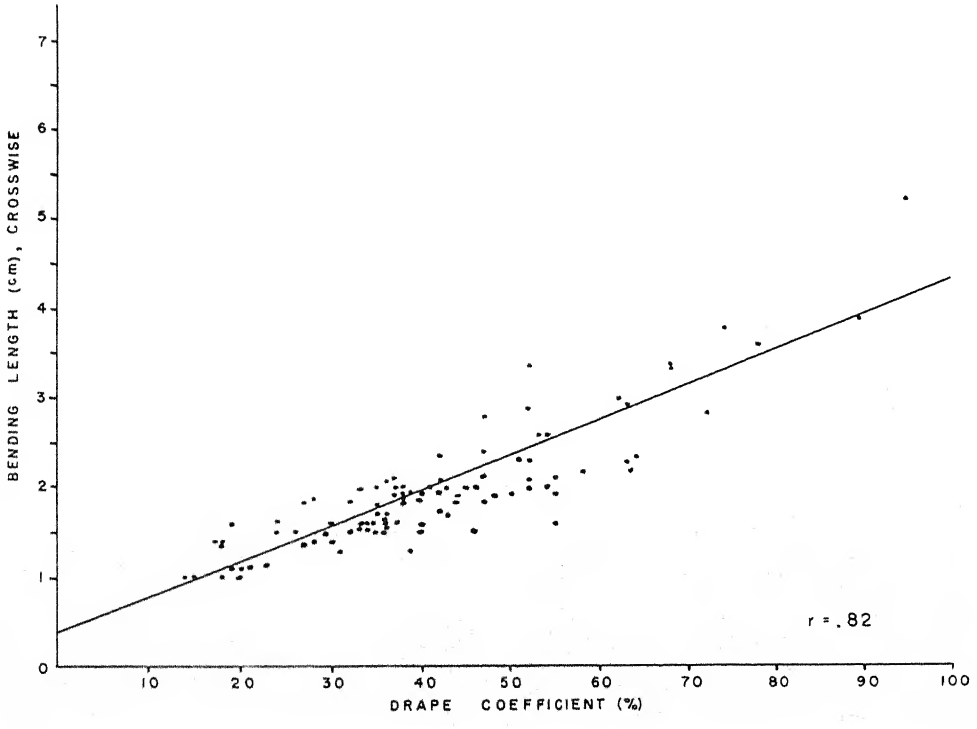

FIGURE 5.—Relation between crosswise bending length and drape coefficient.

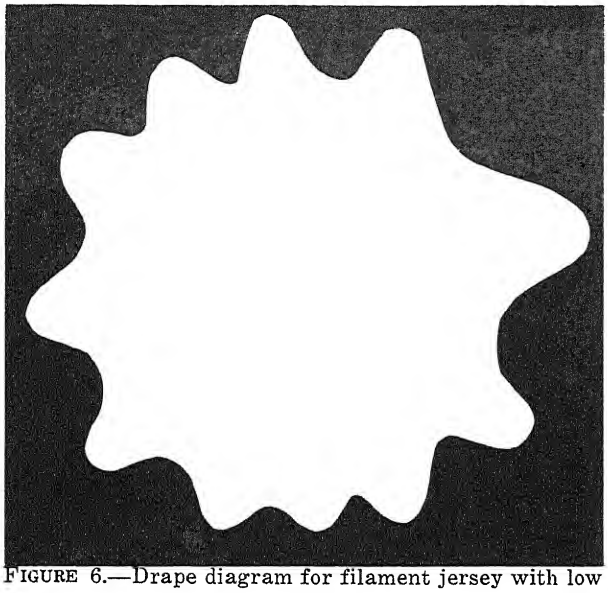

FIGURE 6.—Drape diagram for filament jersey with low drape coefficient.

between the degree of consistency in shape of diagrams and the structural or design details of a fabric.

LITERATURE CITED

(1) American Society for Testing and Materials. ASTM Designations: D 231–62 (reapproved 1975), Standard methods of testing and tolerances for knit goods; D 1388–64 (reapproved 1975), Standard methods of test for stiffness of fabrics; D 1910–64 (reapproved 1975), Standard methods of test for construction characteristics of woven fabrics. The Society, Philadelphia.

(2) Cooper, D. M. E. 1960. The stiffness of woven textiles. J. Text. Inst. 51: T317–335.

(3) Cusick, G. E. 1968. The measurement of fabric drape. J. Text. Inst. 95: 253–260.

(4) Dawes, J. H., and Owen, J. D. 1972. The handle and bending behaviour of fabric laminates. J. Text. Inst. 63: 443–474.

(5) Dowlen, R. P. 1975. Evaluation of experimental cotton acrylic tricot jersey fabrics. *In* Proceedings of the 14th Textile Chemistry and Processing Conference, New Orleans, La., April 29, 30, and May 1, 1974. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS–S–60, pp. 25–50.

(6) General Services Administration. Federal Test Method Standard No. 191. Method 5200, 31 December 1968. Stiffness of cloth, directional; hanging heart loop method.

(7) Hearle, J. W. S. 1969. Shear and drape of fabrics. *In* J. W. S. Hearle, P. Grosberg, and S. Backer (eds.), Structural Mechanics of Fibers, Yarns, and Fabrics. Vol. I, pp. 371–410. Wiley-Interscience, New York.

(8) International Nonwovens and Disposables Association Test Methods Subcommittee. 1974. Softness-hand research study. 16 pp. The Association, New York.

(9) Lundgren H. P. 1969. New concepts in evaluating fabric hand. Text. Chem. Color. 1: 35–45.

(10) Matsuo, T., Nasu, N., and Saito, M. 1971. Study on the hand. J. Text. Mach. Soc. Jap. [English ed.] 17: 92–104.

(11) ———, Harada, T., and Saito, M. 1972. Study on the hand. Part 3: Measurements of the hand of various fabrics. J. Text. Mach. Soc. Jap. [English ed.] 18: 45–54.

(12) Peirce, F. T. 1930. The handle of cloth as a measurable quantity. J. Text. Inst. 21: T377–415.

(13) Skelton, J. 1966. A theoretical and experimental investigation of the stiffness and crease re-

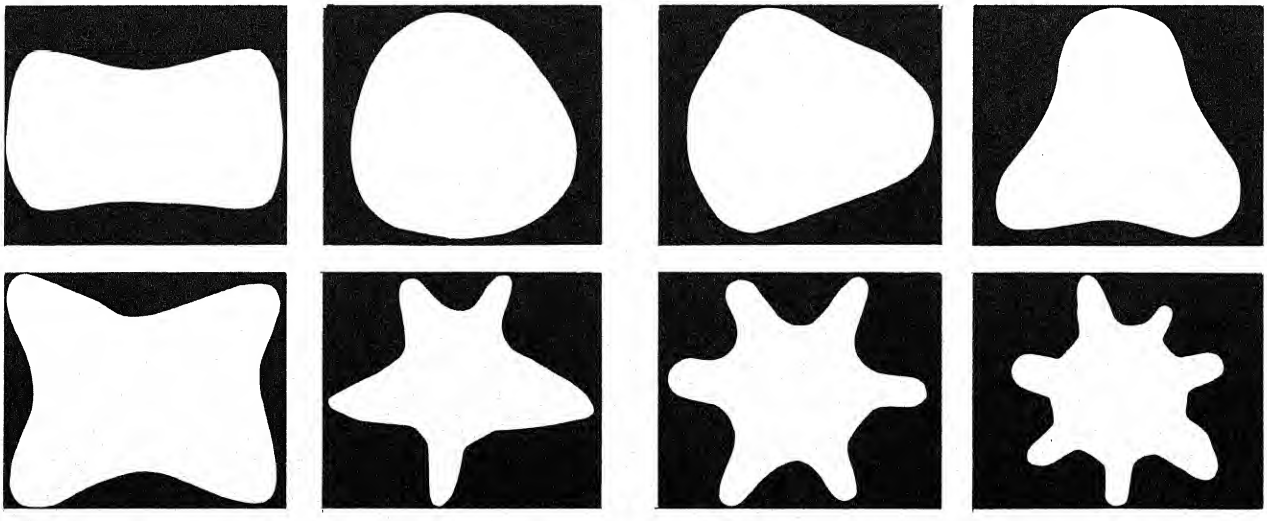

FIGURE 7.—Examples of drape diagrams for apparel fabrics having high to low drape coefficients. (Read left to right, top to bottom.)

covery of monofilament fabrics. Shirley Institute Memoirs 39(4) : 49–64.

(14) Stevens, G. W. H. 1953. Scientific aspects of the design of a full skirt. J. Text. Inst. 44: P247–257.

(15) ———. 1953. The mechanical requirements of stiff cloths for crinolines and similar heavy fabric structures. J. Text. Inst. 44: T347–357.

(16) Suda, N., and Ohira, M. 1972. Studies on drapability of fabrics. Bull. Res. Inst. Polym. Text. 98: 45–50. [In Japanese with brief English abstract, p. 45.]

(17) Sudnik, Z. 1972. Objective measurement of fabric drape. Text. Inst. Ind. 10: 14–18.

(18) Townend, P. P., Harper, R., and Watt, J. D. 1964. Colour streakiness in worsted ingrain blends. J. Text. Inst. 55(1): T352–364; (2) T365–376.

(19) Vaughn, E. A. 1973. Fundamentals of fabric hand: The problem of the objective measurement of a subjective phenomenon. Text. Inf. Sour. Resour. 6(2) : 17–18.

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